that I have done upon this last subject. Observations conducted under varied physiological conditions require to be undertaken, so that besides having the facts as mere chemical facts before us, we may be in a position also to deal with them from a physiological point of view. In a subsequent communication, I will enter further into this matter, and then supply details of the actual quantitative results.

Summary of Conclusions.

Bernardin (glycogen) does not undergo any significant transformation into sugar in contact with blood.

Bernardin exists to a distinctly notable extent as a normal constituent of blood.

The evidence derivable from the observations recorded on the addition of Bernardin to blood and its subsequent recovery, and on its extraction from the liver by boiling water on successive days, and by water at 300° F., tends to show that Bernardin enters into feeble combination with nitrogenous matter.

Bernardin exists in notable amount, not only in muscle, as has been previously known, but also in the spleen, pancreas, kidney, and brain. These are all the structures I have yet examined. It also exists in notable amount in the white and yolk of egg. These several products likewise contain a cupric oxide reducing substance, which is extracted by alcohol, and which, in most instances, possesses the characters of glucose, but, specially in the case of muscle, the characters of maltose.

Through the existence of Bernardin (glycogen) throughout the system, as has been represented, we have a carbohydrate occupying a parallel position to albumen, viz., existing in the colloidal state, and thus adapted for retention within the body, instead of passing off as a diffusible substance as glucose tends to do.

XVIII. "On the Stresses caused in the Interior of the Earth by the Weight of Continents and Mountains." By G. H. Darwin, F.R.S. Received June 11, 1881.

(Abstract.)

In this paper I have considered the subject of the solidity and strength of the materials of which the earth is formed from a point of view from which it does not seem to have been hitherto discussed.

The first part of the paper is entirely devoted to a mathematical investigation, based upon Sir William Thomson's well-known paper on the rigidity of the earth.* The second part consists of a summary and discussion of the preceding work.

* "Thomson and Tait's Nat. Phil.," § 834, or "Phil. Trans.," 1863, p. 573.

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The existence of dry land proves that the earth's surface is not a figure of equilibrium appropriate for the diurnal rotation. Hence the interior of the earth must be in a state of stress, and as the land does not sink in, nor the sea-bed rise up, the materials of which the earth is made must be strong enough to bear this stress.

We are thus led to inquire how the stresses are distributed in the earth's mass, and what are magnitudes of the stresses.

In this paper I have solved a problem of the kind indicated for the case of a homogeneous incompressible elastic sphere, and have applied the results to the case of the earth.

If the earth be formed of a crust with a semi-fluid interior, the stresses in that crust must be greater than if the whole mass be solid, very far greater if the crust be thin. As regards the condition of incompressibility attributed to the materials of the earth, it is proved in this paper that the compressibility of the solid would make no sensible difference in the results; except, indeed, in the case where the deformation of the sphere is of the second spherical harmonic class, when large compressibility would considerably modify the results.

The strength of an elastic solid is here estimated by the difference between the greatest and least principal stresses, when it is on the point of breaking, or, according to the phraseology adopted, by the breaking stress-difference. The most familiar examples of breaking stress-difference are when a wire or rod is stretched or crushed until it breaks; then the breaking load divided by the area of the section of the wire or rod is the measure of the strength of the material. Stress-difference is thus to be measured by tons per square inch.

Tables of breaking stress-differences for various materials are given in the paper.

The problem is only solved for the class of inequalities called zonal harmonics; these consist of a number of waves running round the globe in parallels of latitude. The number of waves is determined by the order of the harmonic. In the application to the earth the equator here referred to may be any great circle, and is not necessarily the terrestrial equator. The second harmonic has only a single wave, and consists of an elevation at an equator and depression at the pole; this constitutes ellipticity of the spheroid. An harmonic of a high order may be described as a series of mountain chains, with intervening valleys, running round the globe in parallels of latitude, estimated with reference to the chosen equator.

The case of the second harmonic is considered in detail, and it is shown that the stress-difference rises to a maximum at the centre of the globe, and is constant all over the surface. The central stress-difference is eight times as great as the superficial.

On evaluating the stress-difference arising from given ellipticity in a rotating spheroid of the size and density of the earth, it appears that

if the excess or defect of ellipticity above or below the equilibrium value were $\frac{1}{1000}$, then the stress-difference at the centre would be 8 tons per square inch; and that, if the sphere were made of material as strong as brass, it would be just on the point of rupture. Again, if the homogeneous earth, with ellipticity $\frac{1}{232}$, were to stop rotating, the central stress-difference would be 33 tons per square inch, and it would rupture if made of any material excepting the finest steel.

The stresses produced by harmonic inequalities of high orders are next considered. This is in effect the case of a series of parallel mountains and valleys, corrugating a mean level surface with an infinite series of parallel ridges and furrows.

It is found that the stress-difference depends only on the depth below the mean surface, and is independent of the position of the point considered with regard to ridge and furrow.

Numerical calculation shows that if we take a series of mountains, whose crests are 4,000 meters, or about 13,000 feet, above the intermediate valley bottoms, formed of rock of specific gravity 2·8, then the maximum stress-difference is 2·6 tons per square inch (about the tenacity of cast tin); also if the mountain chains are 314 miles apart, the maximum stress-difference is reached at 50 miles below the mean surface.

The solution shows that the stress-difference is *nil* at the surface. It is, however, only an approximate solution, for it will not give the stresses actually in the mountain masses, but it gives correct results at some three or four miles below the mean surface.

The cases of the harmonics of the 4th, 6th, 8th, 10th, and 12th orders are then considered; and it is shown that, if we suppose them to exist on a sphere of the mean density and dimensions of the earth, and that the height of the elevation at the equator is in each case 1,500 meters above the mean level of the sphere, then in each case the maximum stress-difference is about 4 tons per square inch. This maximum is reached in the case of the 4th harmonic at 1,150 miles, and for the 12th at 350 miles, from the earth's surface.

In the second part of the paper it is shown that the great terrestrial inequalities, such as Africa, the Atlantic Ocean, and America, are represented by an harmonic of the 4th order; and that, having regard to the mean density of the earth being about twice that of superficial rocks, the height of the elevation is to be taken as about 1,500 meters.

Four tons per square inch is the crushing stress-difference of average granite, and accordingly it is concluded that at 1,000 miles from the earth's surface the materials of the earth must be at least as strong as granite. A very closely analogous result is also found from the discussion of the case in which the continent has not the regular wavy character of the zonal harmonics, but consists of an equatorial elevation with the rest of the spheroid approximately spherical.

From this we may draw the conclusion, that either the materials of the earth have about the strength of granite at 1,000 miles from the surface, or they have a much greater strength nearer to the surface.

This investigation must be regarded as confirmatory of Sir William Thomson's view, that the earth is solid nearly throughout its whole mass. According to this view, the lava which issues from volcanoes arises from the melting of solid rock, existing at a very high temperature, at points where there is a diminution of pressure, or else from comparatively small vesicles of rock in a molten condition.

XIX. "On the Refraction of Electricity." By ALFRED TRIBE, F.I.C., Lecturer on Chemistry in Dulwich College. Communicated by Dr. GLADSTONE, F.R.S. Received June 7, 1881.

On December 15, 1880, I had the honour of communicating to the Royal Society the latest results of my work on electric distribution. In that paper there is included a description of results which form the basis of a graphic and electro-chemical method of investigating the field of electrolytic action. These results may be classed under three heads:—1st. Distribution of electricity on metallic conductors in electrolytic media. 2nd. Physical differences in corresponding parts of non-homogeneous electrolytic fields. 3rd. Direction in which the energy is transmitted.

As the detailed account of these experiments has not yet been published, it is necessary for the appreciation of the evidence to be adduced to give in this place the groundwork of that part of the method relating to the direction in which the energy is transmitted. It will be convenient to do this under three heads. Let it be remembered that a rectangular electrolytic cell was used, that the electrolyte was a solution of copper sulphate, and the electrical relations of the liquid were ascertained by immersing in it a rectangular silver plate (called an *analysing plate* or *analyser*), on which the ions were deposited. In all cases the positive ion separates and is distributed on that part of the plate which may be supposed to receive — electrification, or by which the + energy enters the analyser, while the — ion separates on that part of the same plate which receives + electrification, or from which the energy emerges.

α. When the course of the energy* is parallel with any two edges of an analyser, and therefore with the sides, the boundary lines of the ions on both sides of the plate are parallel with the plane of the elec-

* I assume that the energy in a homogeneous field runs in straight parallel lines from one electrode to another, and that this course is not appreciably disturbed by an analyser.